# Soil Organic Matter Stratification under Pastures

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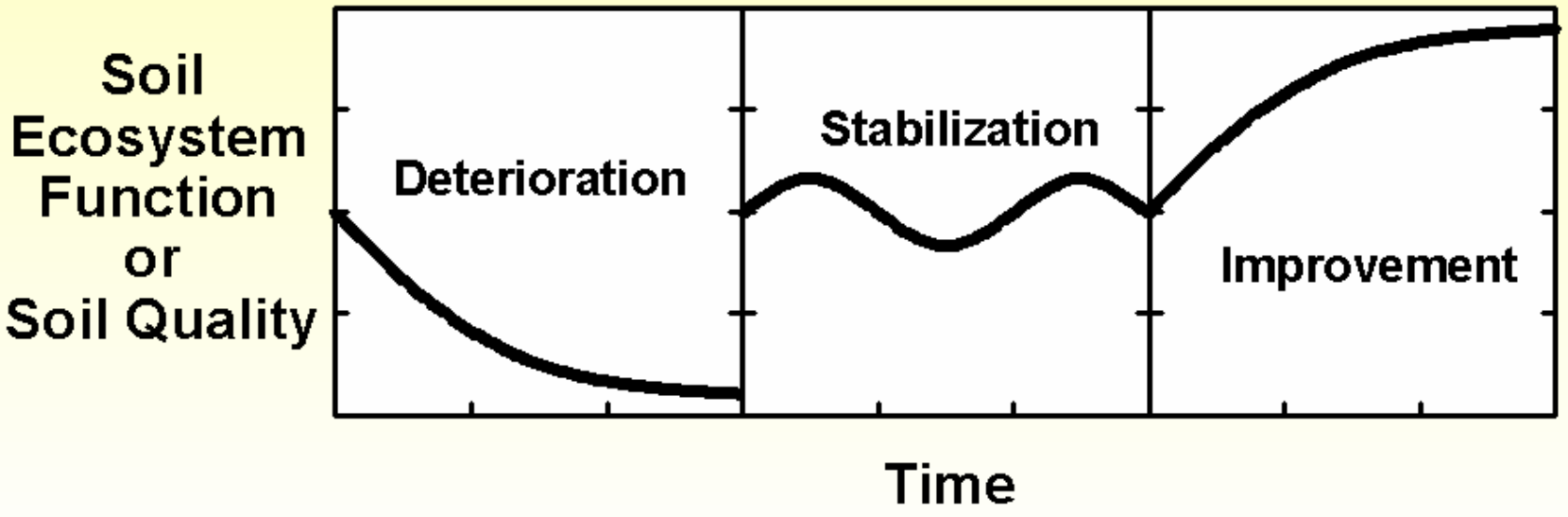
# Rationale

- ✔ Soil quality is a concept based on the premise that management can deteriorate, stabilize, or improve soil ecosystem function.



# Rationale

- ✔ Soil organic matter (SOM) sustains many key soil functions by
  - providing
    - – energy,
    - – substrates, and
    - – biological diversity

    to support biological activity
  - all of which affect
    - – aggregation (soil erosion, habitat, oxygen supply)
    - – infiltration (leaching, runoff, crop water uptake)
    - – decomposition (nutrient cycling, detoxification)

# Rationale

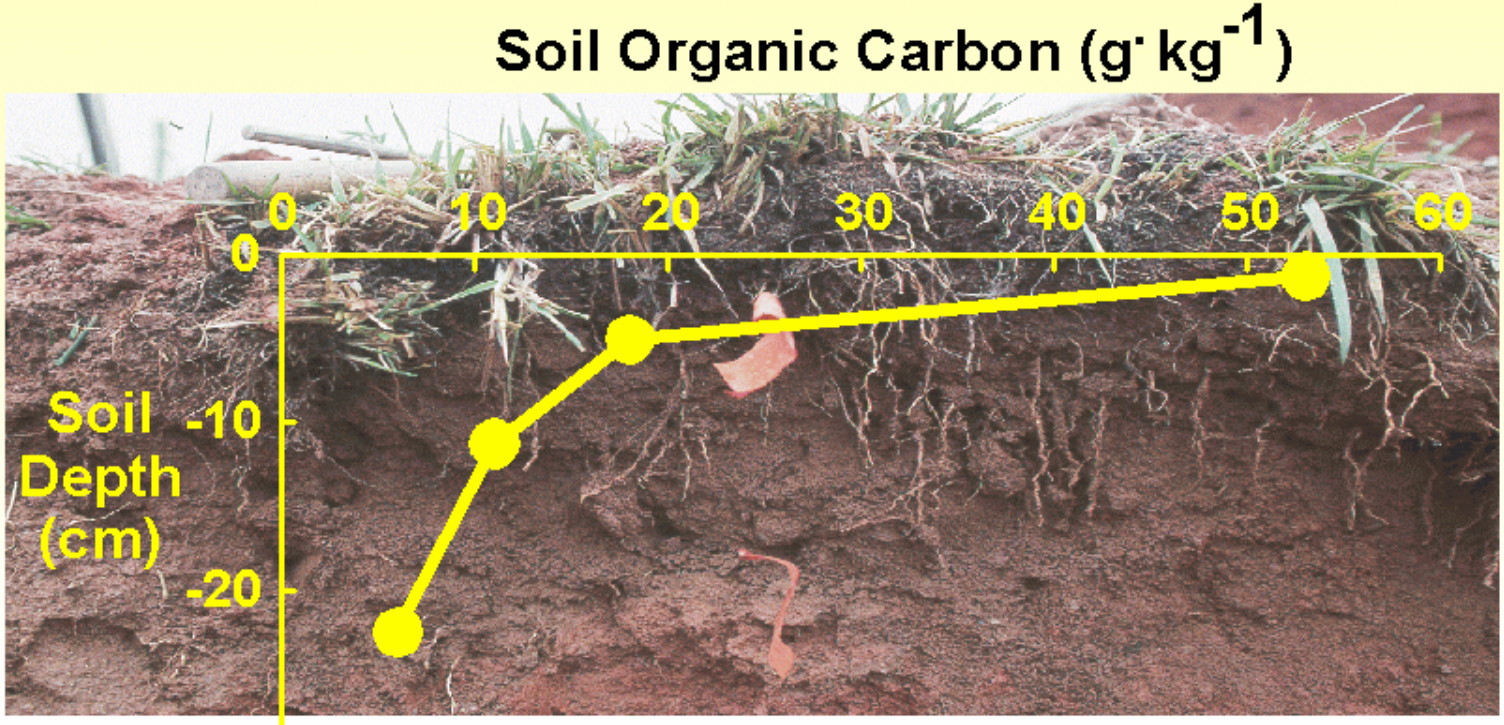
- ✔ Lack of residue cover and exposure of soil to high-intensity rainfall leads to:
  - poor aggregation
  - reduced plant-water availability
  - erosion
  - off-site impacts
    - Sedimentation
  - poor water quality
- ✔ Characteristics of poor soil quality

# Rationale

- ✔ Degree of stratification of soil organic C and N pools with depth, expressed as a ratio, could indicate soil quality or soil ecosystem function.
- ✔ Stratification ratios would allow a wide diversity of soils to be compared on the same assessment scale, because of internal normalization that accounts for inherent soil differences.

# Hypothesis

- ✔ Grass-based agricultural systems may improve soil quality and this could be recognized by high stratification ratios.



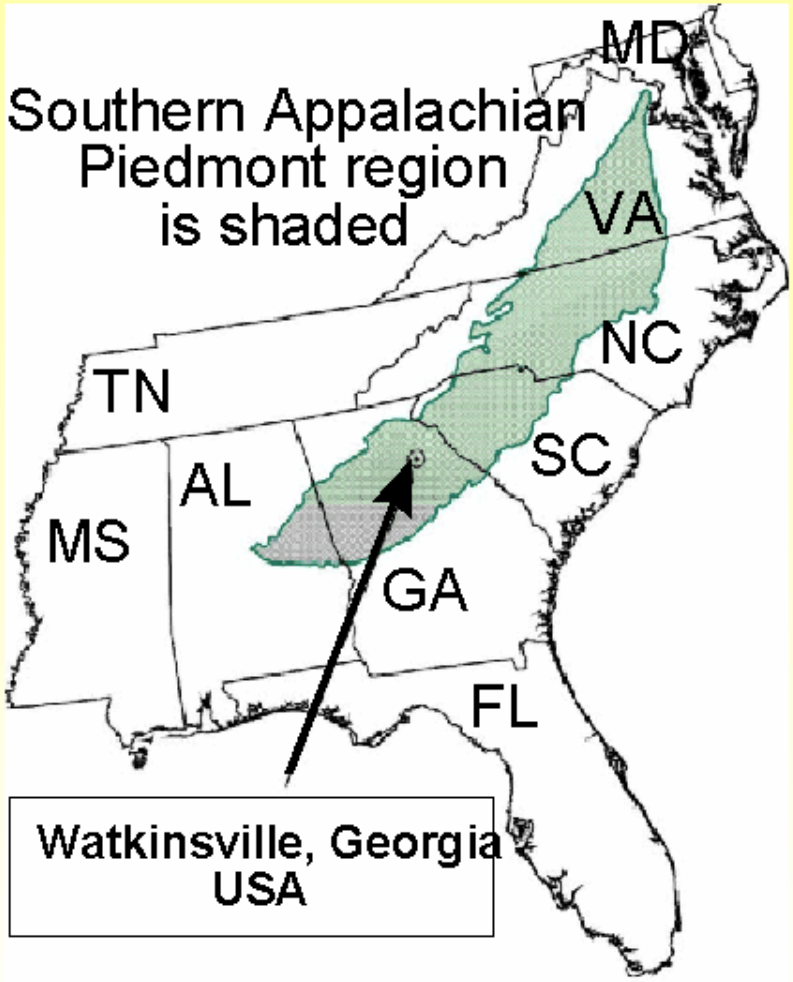
# Objectives

- ✔ Determine the effect of various forage and pasture management strategies on the stratification ratio of soil organic C and N pools.
- ✔ Identify the most dynamic soil C and N components that respond to management.

# Materials and Methods

## 1. Environmental conditions

- ✔ 16.5 °C – mean annual temperature
- ✔ 125 cm – mean annual precipitation
- ✔ 156 cm – mean annual pan evaporation
- ✔ Clayey, kaolinitic, thermic Typic Kanhapludults



# Materials and Methods

## 2. Management comparison (cropland *vs* grazingland)

Conservation-tillage cropland (24-yr-old)

Grazed tall fescue-common bermuda grass (20-yr-old)

# Materials and Methods

## 2. Management comparison (haying *vs* grazing)

Hayed bermuda grass
(15-19-yr-old)

Grazed bermuda grass
(15-19-yr-old)

# Materials and Methods

## 2. Management comparison (years of grazing)

- ✔ Chronosequence of grazed ‘K-31' tall fescue pasture (10, 17, and 50-yr-old)
- ✔ Chronosequence of hayed ‘Coastal’ bermudagrass (6, 12, and 40-yr-old)

# Materials and Methods

## 2. Management comparison (long-term land use)

Cropland
(24-yr-old)

Hayland
(40-yr-old)

Grazingland
(50-yr-old)

Forestland
(130-yr-old)

# Materials and Methods

## 2. Management comparison (first 5 years of forage mgt)

✔ Conversion of degraded cropland to forage management with either:

- Unharvested
- Low grazing pressure
- High grazing pressure
- Hayed


Forage utilization

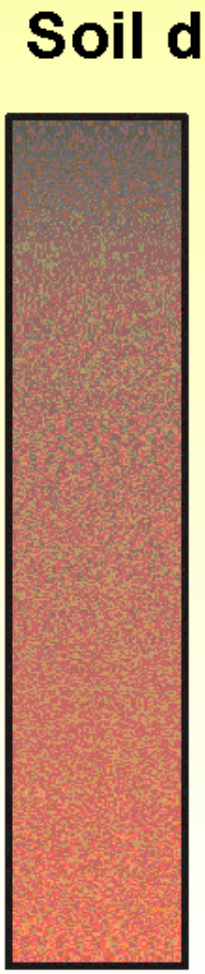
# Materials and Methods

## 3. Soil analyses

- ✔ Soil organic C and N
  - Dry combustion
- ✔ Particulate organic C and N
  - Dry combustion of material collected on a 0.05-mm screen following dispersion
- ✔ Soil microbial biomass C
  - Chloroform fumigation–incubation w/o control
- ✔ Potential C and N mineralization
  - Soil incubated at 25 °C and 50% WFPS for 24 days

# Materials and Methods

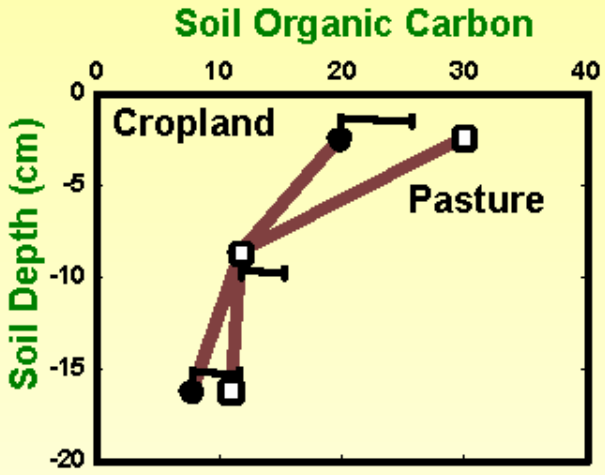
## 4. Calculation of stratification ratios




- ✔ Concentration of soil property at 0-5-cm depth divided by concentration at 12.5-20-cm depth.
- ✔ Soil property near the bottom of the ‘plow layer’ should reflect an inherent characteristic to normalize each soil.

# Results

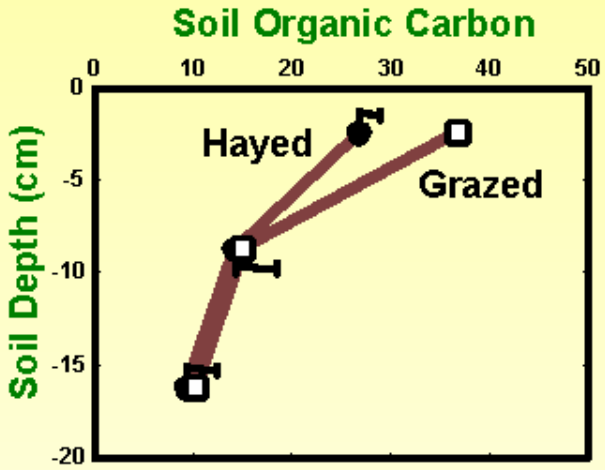
## 1. Cropland *vs* grazingland




| Stratification ratio of (0-5 cm) / (12.5-20 cm): | Conservation tillage | | Tall fescue pasture |
|---|---|---|---|
| Soil organic C | 3.5 | ns | 4.0 |
| Particulate organic C | 6.2 | ** | 11.5 |
| Soil microbial biomass C | 3.1 | ns | 2.6 |
| Potential C mineralization | 25.5 | ns | 20.6 |

# Results

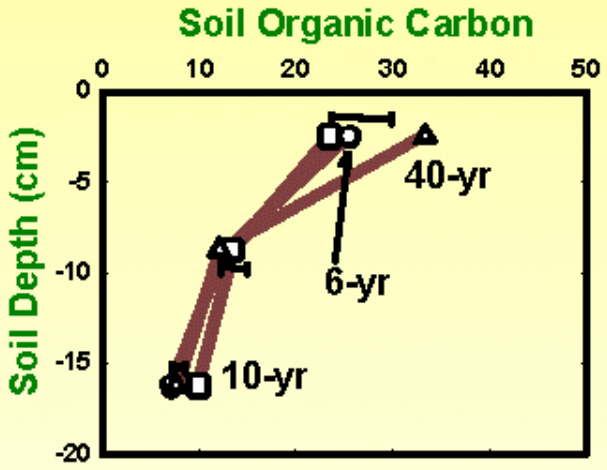
## 2. Haying *vs* grazing




| Stratification ratio of (0-5 cm) / (12.5-20 cm): | Hayed | | Grazed |
|---|---|---|---|
| Soil organic C | 4.9 | ns | 6.0 |
| Particulate organic C | 11.5 | ** | 18.0 |
| Soil microbial biomass C | 3.3 | ns | 3.7 |
| Potential C mineralization | 20.4 | ns | 17.4 |

# Results

## 3. a. Chronosequence of hayed bermudagrass

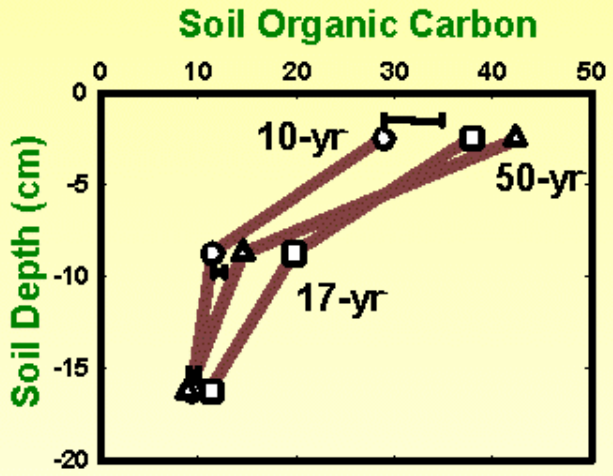




| Stratification ratio of (0-5 cm) / (12.5-20 cm): | Hayed bermudagrass chronosequence 6 yr | 12 yr | 40 yr | |
|---|---|---|---|---|
| Soil organic C | 4.3 | 3.7 | 6.8 | * |
| Particulate organic C | 8.4 | 10.2 | 10.5 | ns |
| Soil microbial biomass C | 3.2 | 2.9 | 4.2 | * |
| Potential C mineralization | 24.4 | 15.7 | 12.6 | * |

# Results

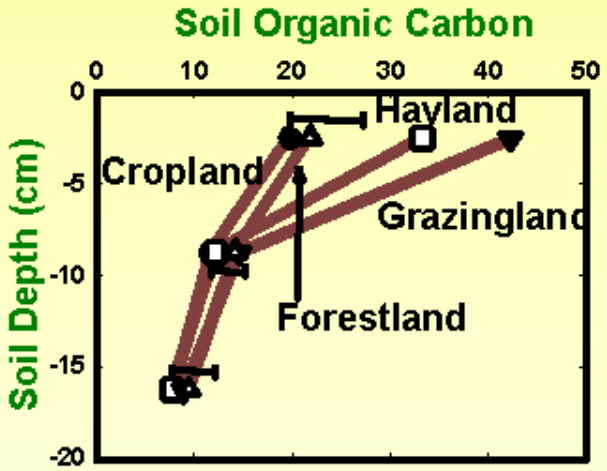
## 3. b. Chronosequence of grazed tall fescue




| Stratification ratio of (0-5 cm) / (12.5-20 cm): | Grazed tall fescue chronosequence 10 yr | 17 yr | 50 yr | |
|---|---|---|---|---|
| Soil organic C | 4.7 | 5.0 | 7.5 | * |
| Particulate organic C | 12.3 | 11.0 | 17.8 | * |
| Soil microbial biomass C | 3.8 | 3.0 | 5.2 | * |
| Potential C mineralization | 20.4 | 16.3 | 15.9 | ns |

# Results

## 4. Long-term land use




Surface residue C (Mg/ha)

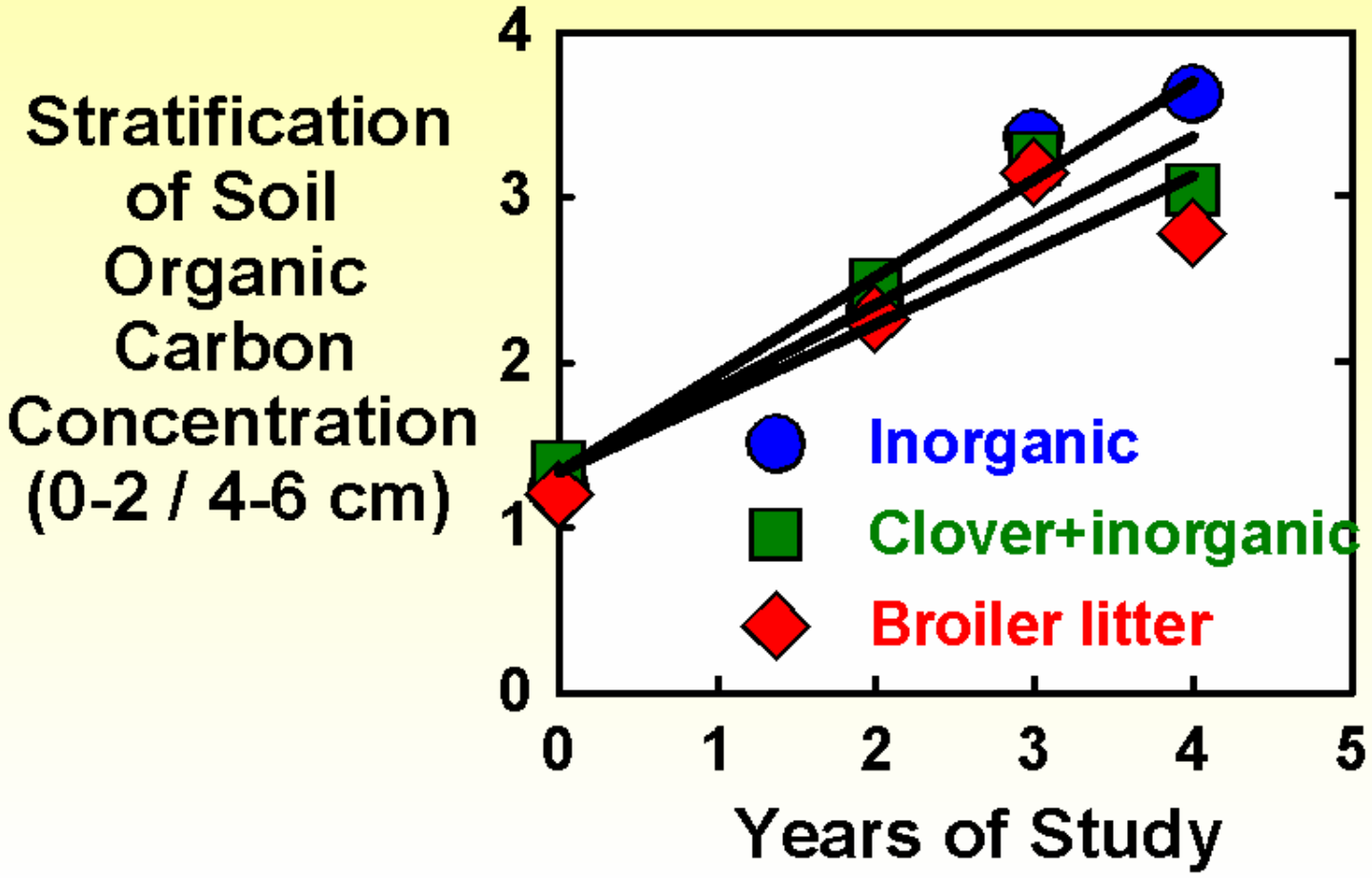
0.2 0.3 0.2 1.9




| Stratification ratio of (0-5 cm) / (12.5-20 cm): | $LSD_{(p=0.05)}$ | Cropland | Hayland | Grazingland | Forestland |
|---|---|---|---|---|---|
| Soil organic C | 2.0 | 3.5 | **6.8** | **7.5** | 3.9 |
| Particulate organic C | 4.1 | 6.2 | 10.5 | **17.8** | 4.2 |
| Soil microbial biomass C | 1.4 | 3.1 | **4.2** | **5.2** | 2.7 |
| Potential C mineralization | 13.4 | 25.6 | 12.6 | 15.9 | 13.0 |

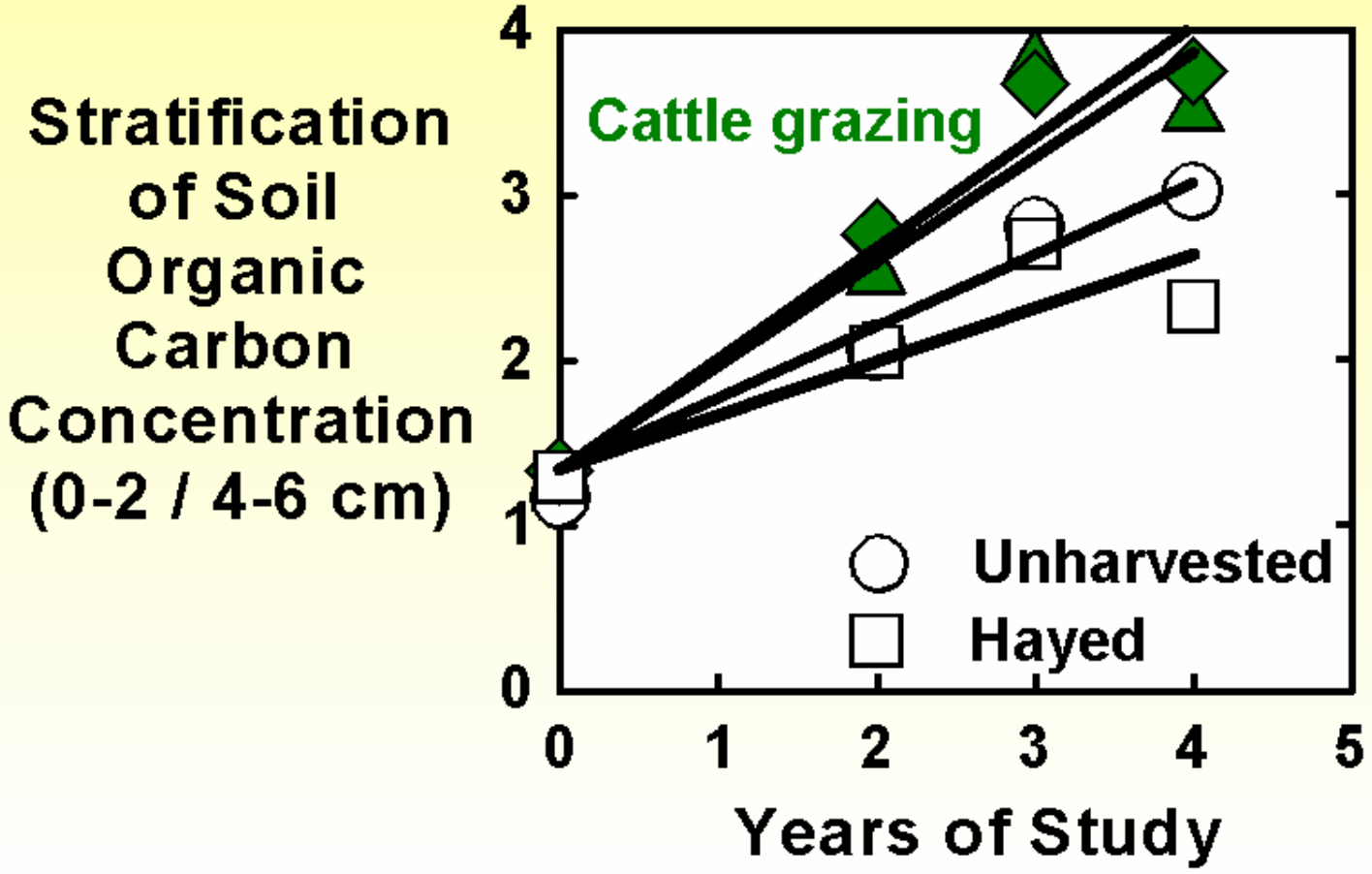
# Results

5. First 5 years of forage management
   a. Effect of fertilization type



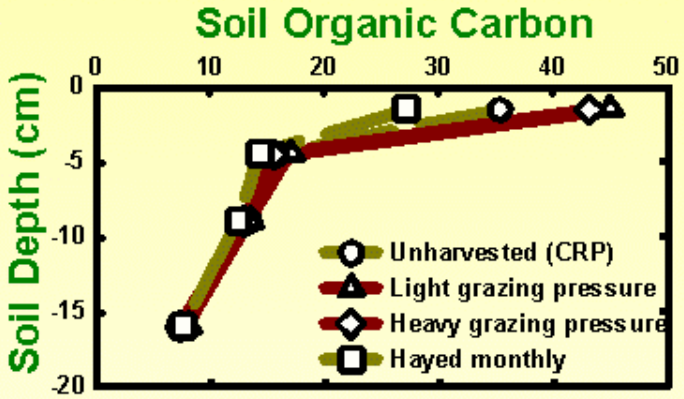
# Results

5. First 5 years of forage management
   b. Effect of harvest strategy

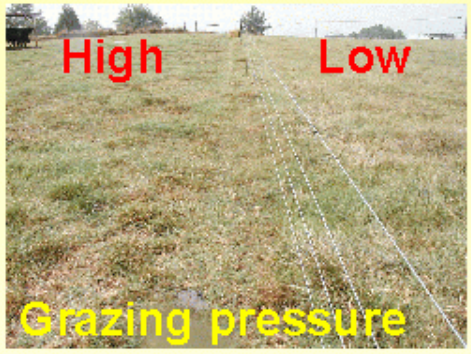


# Results

## 5. First 5 years of forage management
### c. Effect of harvest strategy at the end of 5 years








| Stratification ratio of (0-6 cm) / (12-20 cm): | LSD (p=0.05) | Un harvested | Grazing: Low Pressure | Grazing: High Pressure | Hayed |
|---|---|---|---|---|---|
| Soil organic C | 0.7 | 3.4 | 3.6 | 3.6 | **2.7** |
| Total soil N | 1.7 | 6.7 | 7.1 | 7.3 | **5.3** |
| Bulk density | 0.04 | 0.77 | 0.77 | 0.82 | **0.83** |

# Results

## 6. Sensitivity of soil properties to stratification

- ✔ Sensitivity was calculated as the ratio of F-values from known-to-unknown variability; highest values indicate greatest sensitivity.

| | | | |
|---|---|---|---|
| Soil microbial biomass C | 4.3 a | Potential N mineralization | 3.1 abc |
| Particulate organic N | 3.5 ab | Potential C mineralization | 3.1 abc |
| Particulate organic C | 3.5 ab | Soil inorganic N | 2.3 bc |
| Total organic C | 3.4 ab | Flush of $CO_2$ in 3 days | 2.2 bc |
| Total soil N | 3.2 abc | Non-particulate organic N | 1.7 bc |
| Soil bulk density | 3.1 abc | Non-particulate organic C | 1.4 c |

# Summary

- ✔ Stratification of soil properties with depth is a consequence of conservation management that supplies organic residues at the soil surface resulting in:
  - protection of the soil surface from erosion
  - concentration of substrates to enhance biodiversity
  - development of biologically supported physico-chemical processes (e.g., aggregation, nutrient cycling)

# Summary

- ✔ Land management with cattle grazing resulted in stratification ratios that were as high or higher than:
  - conservation-tillage cropland
  - haying to remove grass without animal traffic
  - natural forestland
- ✔ Soil organic C and N pools became quickly stratified under pastures following conversion from degraded cropland.

# Conclusion

- ✔ Prediction of optimum soil quality with stratification ratios is still premature, but the average soil organic C stratification ratio of 5 under the various pasture systems evaluated here might be a reasonable target.